National Aeronautics and Space Administration

NASA's Human Landing System

Dr. Greg Chavers

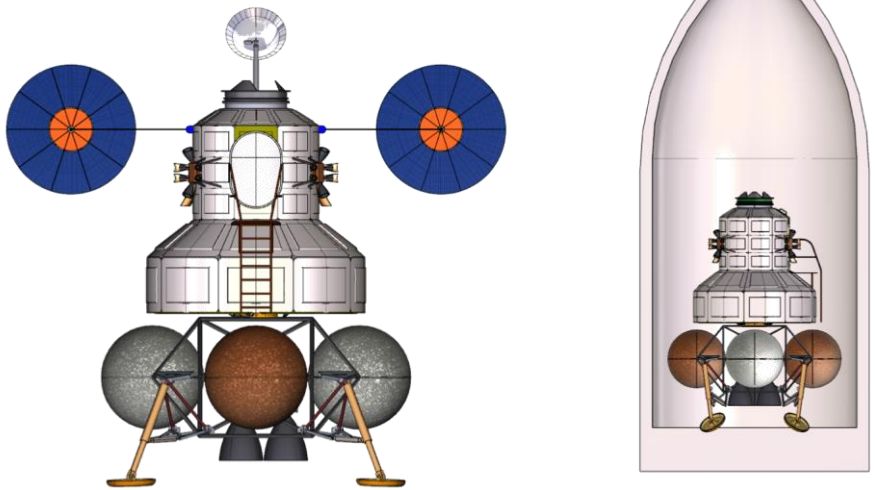
Deputy Program Manager

Human Landing System Program

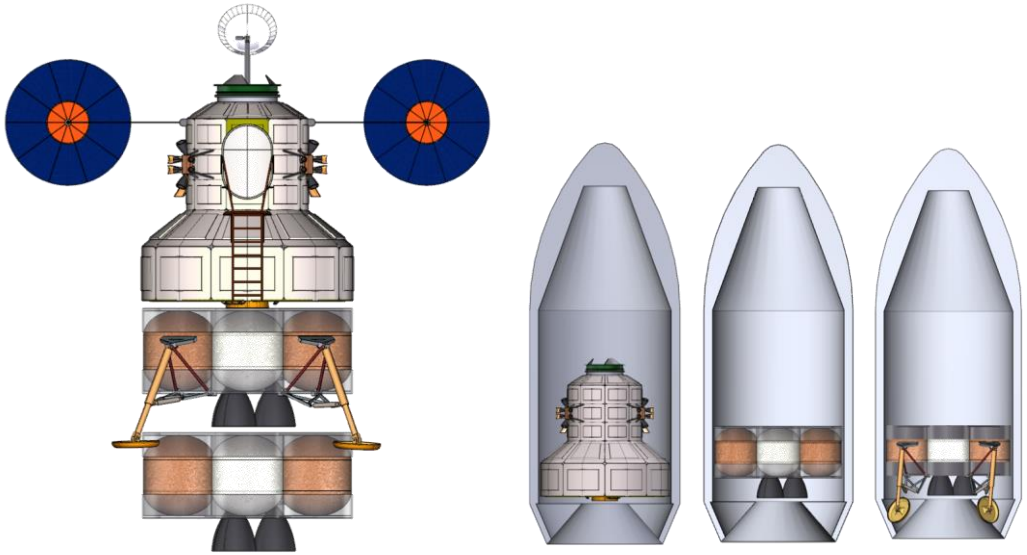
ARTEMIS

Fast Delivery to the Moon

Two-Element Architecture



Three-Element Architecture

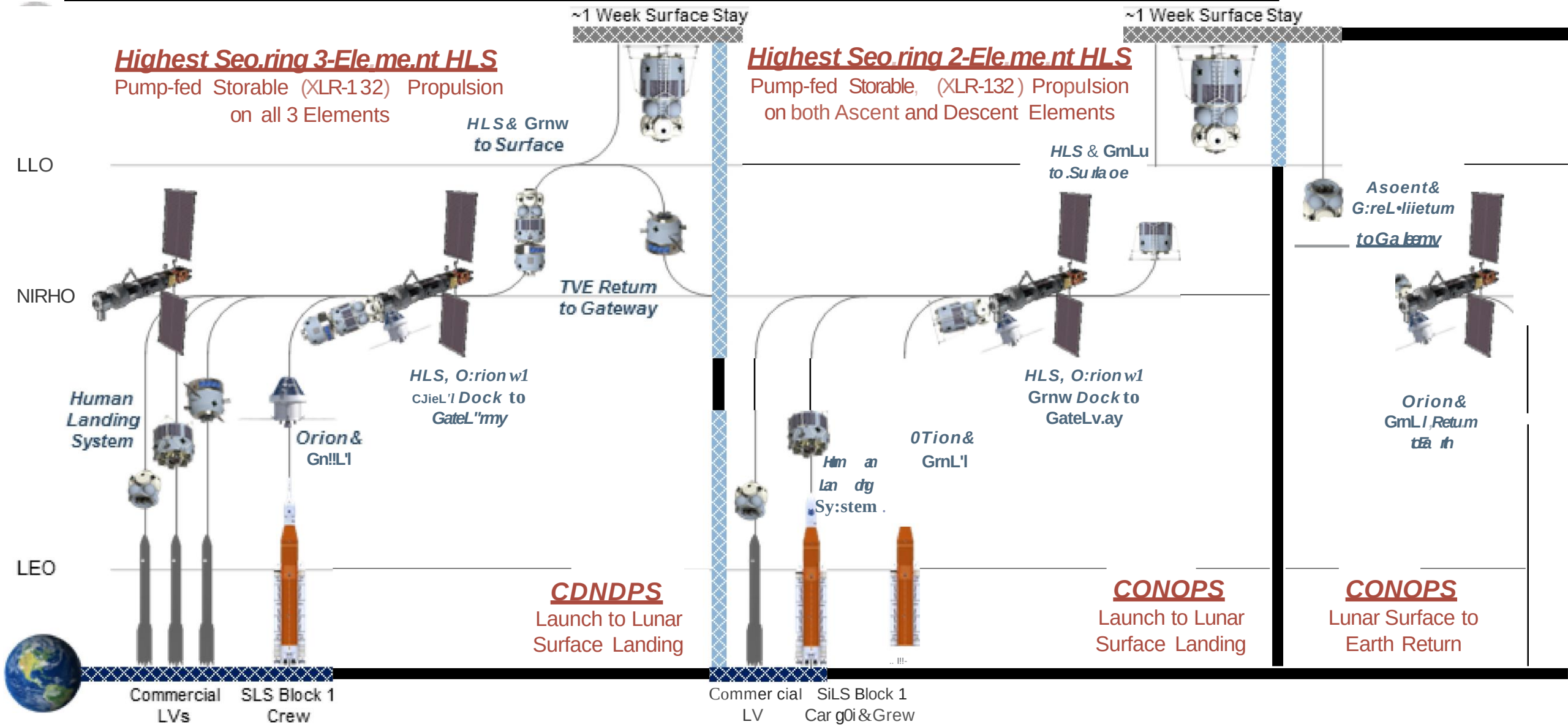


Appendix E Studies: HLS Concepts of Operation

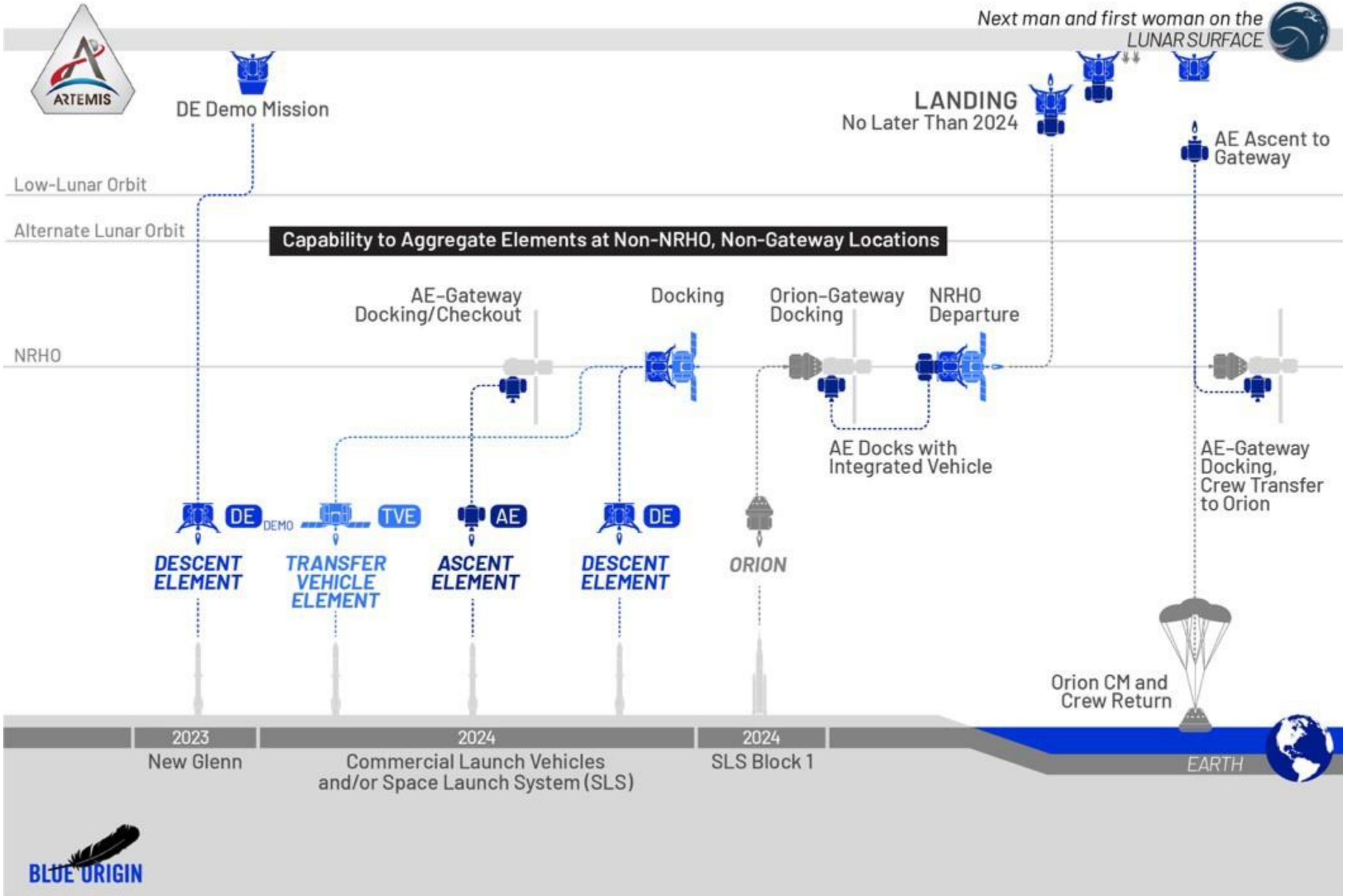
- 11 U.S. Companies to advance human lunar landers, started summer 2019
- App E companies were allowed to update their concepts based on Appendix H requirements

- **Aerojet Rocketdyne** – Canoga Park, CA
- **Blue Origin** – Kent, WA
- **Boeing** – Houston, TX
- **Dynetics** – Huntsville, AL
- **Lockheed Martin** – Littleton, CO
- **Masten Space Systems** – Mojave, CA
- **Northrop Grumman Innovation Systems** – Dulles, VA
- **OrbitBeyond** – Edison, NJ
- **Sierra Nevada Corporation** – Louisville, CO and Madison, WI
- **SpaceX** – Hawthorne, CA
- **SSL** – Palo Alto, CA

NextStep-2 App. E HLS Architecture CONOPS

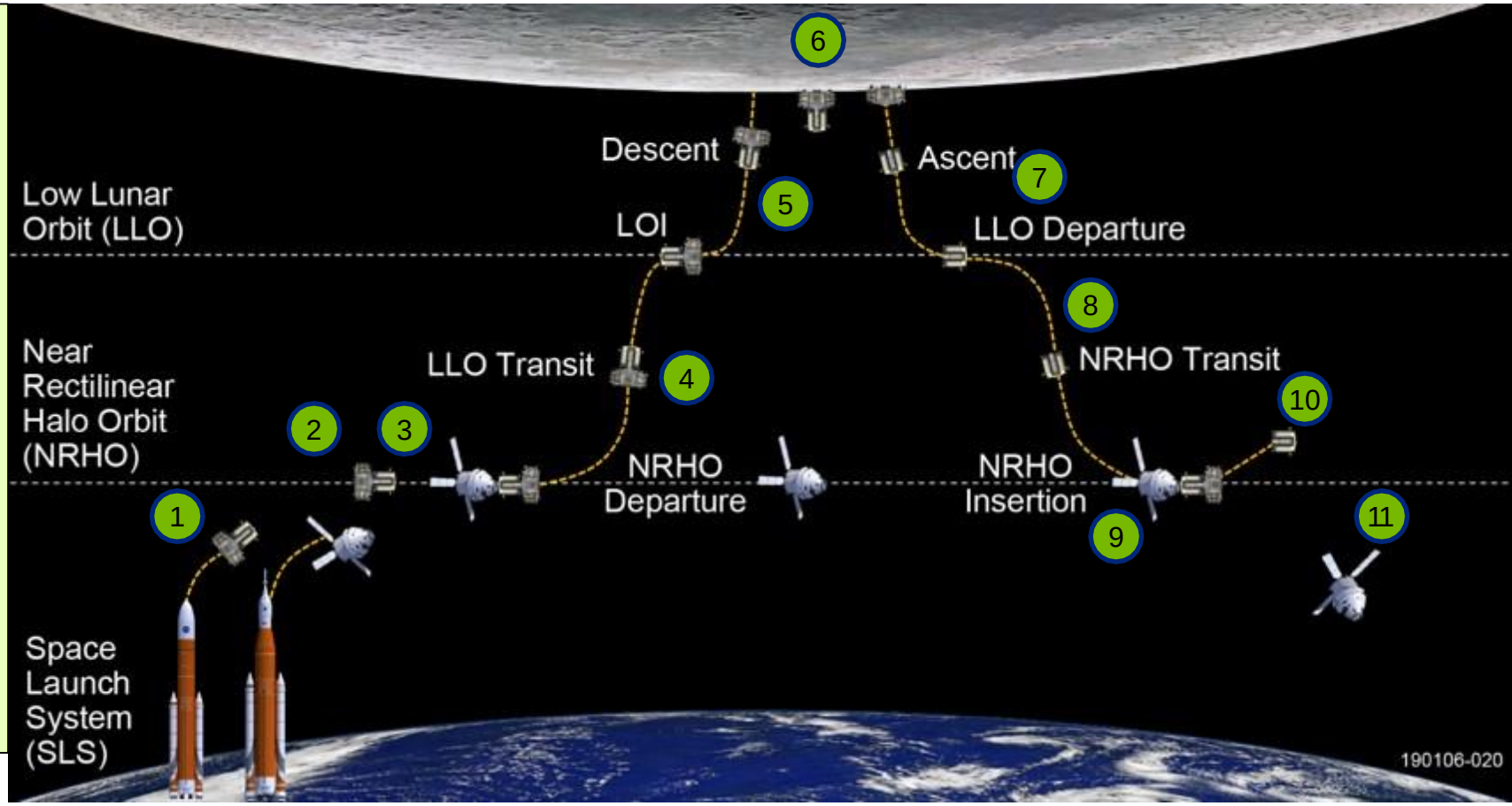


Utility and Uncertainty Analysis Used to Determine Highest Scoring HLS Architectures


ARTEMIS
DE Demo Mission
Next man and first woman on the LUNAR SURFACE
LANDING
No Later Than 2024
AE Ascent to Gateway
Low-Lunar Orbit
Alternate Lunar Orbit
Capability to Aggregate Elements at Non-NRHO, Non-Gateway Locations
AE-Gateway Docking/Checkout
Docking
Orion-Gateway Docking
NRHO Departure
NRHO
AE Docks with Integrated Vehicle
AE-Gateway Docking, Crew Transfer to Orion
DE
DEMO
TVE
AE
DE
DESCENT ELEMENT
TRANSFER VEHICLE ELEMENT
ASCENT ELEMENT
DESCENT ELEMENT
ORION
Orion CM and Crew Return
2023
New Glenn
2024
Commercial Launch Vehicles and/or Space Launch System (SLS)
2024
SLS Block 1
EARTH
BLUE ORIGIN

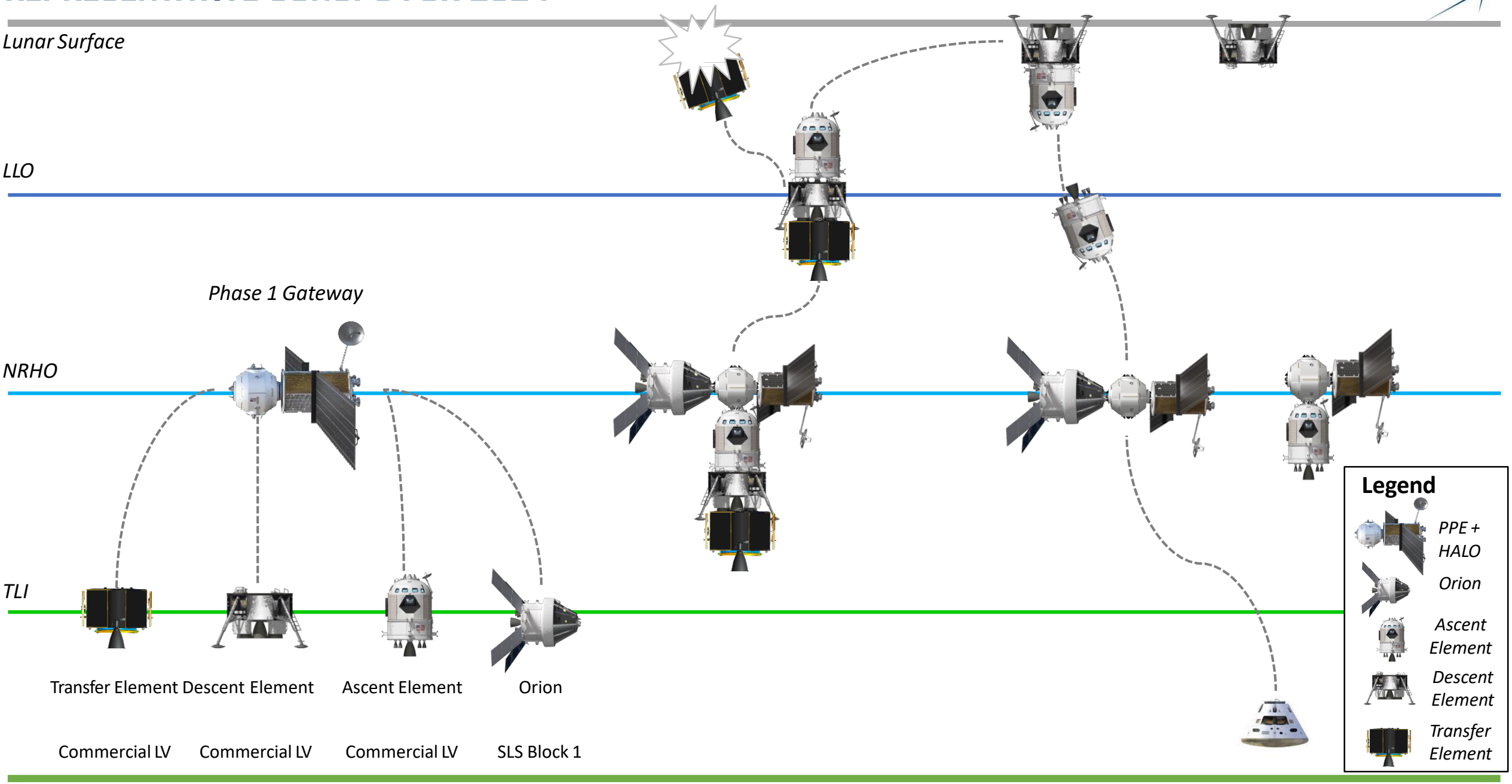
Boeing HLS ConOps Summary - 2024

1. Integrated AE-DE launched on an SLS derived commercial HLS launch vehicle
2. AE-DE enter NRHO; provides a "Go" for Orion crew launch
3. Orion docks with the AE-DE
4. AE-DE separates from Orion; departure burn to transfer to LLO
5. AE-DE de-orbit initiation burn, powered descent, and Lunar landing
6. Surface Stay (~7.3 Days)
7. AE ascent burn to LLO
8. AE transits to NRHO
9. Orion docks with the AE
10. AE separates from Orion to disposal orbit
11. Orion returns to Earth



REPRESENTATIVE CONOPS FOR 2024

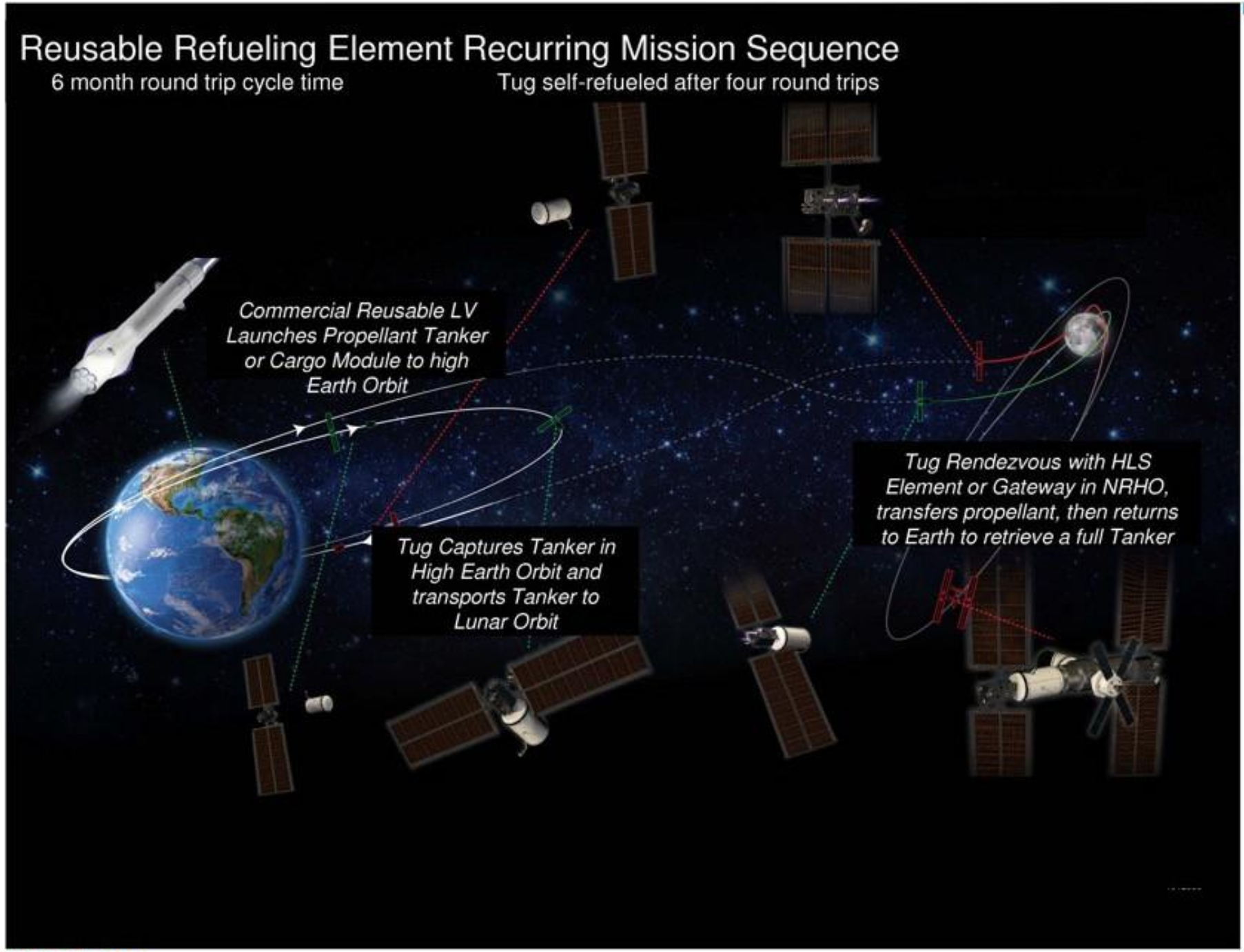
LOCKHEED MARTIN



Reusable Refueling Element Recurring Mission Sequence

6 month round trip cycle time

Tug self-refueled after four round trips



MAXAR

NORTHROP GRUMMAN

6.5 days Surface Stay

Moon

Descent & Landing

LLO

Ascent

Transit to LLO

NRHO

Lunar Transit

Aggregation at Gateway

Split descent & disposable TE distribute delta-V and reduce DE mass

TLI

GTO

Earth

Orion

Ascent Element (AE)

Descent Element (DE)

Transfer Element (TE)

Rapid prototypes reduce risk for 2024

- Long Duration Cryogenic TankSet
- Cryogenic Fluid Management System
- Descent and Landing Software
- Cislunar System Integration Lab
- Gateway Refueling Connector Mechanism

Human Landing System – NextSTEP-2 Appendix H

- Firm Fixed-Price, milestone-based proposals for design, delivery, and demonstration
- Final solicitation issued September 30
  - Drafts issued July 19 and August 30; +1,150 comments from industry
- Proposals submitted November 5, 2019
- Selections announcement Spring 2020

ARTEMIS

Let’s go.
The time is now.

We have the capability

We have the purpose

We have the charge

We have the responsibility


NASA
ARTEMIS